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(54) Abstract Title
Manufacturing an optical waveguide device using an inductively coupled plasma

(57) An optical waveguide device is manufactured using an inductively coupled plasma in which a lower cladding layer 200 (Fig 5) and a core layer 300 are sequentially formed on a substrate 100, and a metal (eg Cr or Ti) mask pattern 550 is formed on the core layer. The substrate is loaded on to a cathode electrode 600 (Fig 7) of an inductively coupled plasma system which includes a DC biassed upper electrode 700. A plasma from a reaction gas (eg CF_4 or SF_6) is generated by applying first 800 and second radio frequency (RF) power respectively to the cathode electrode 600 and an inductively coupled plasma coil 900 to etch the pattern of an optical waveguide 350 (Fig 8) in the exposed core layer 300. Then an upper cladding layer 250 (Fig 8) is formed on the optical waveguide 350.

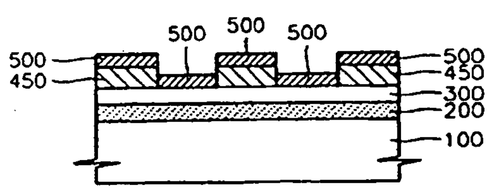

FIG. 5

FIG. 7

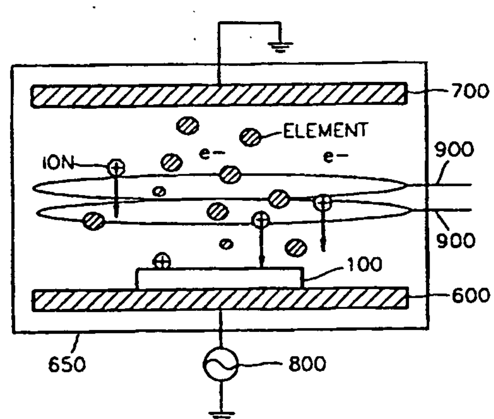

FIG. 8

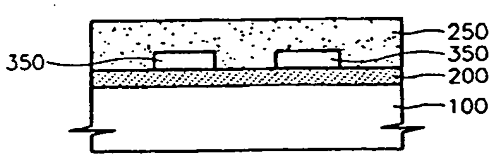

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FIG. 1 (PRIOR ART)

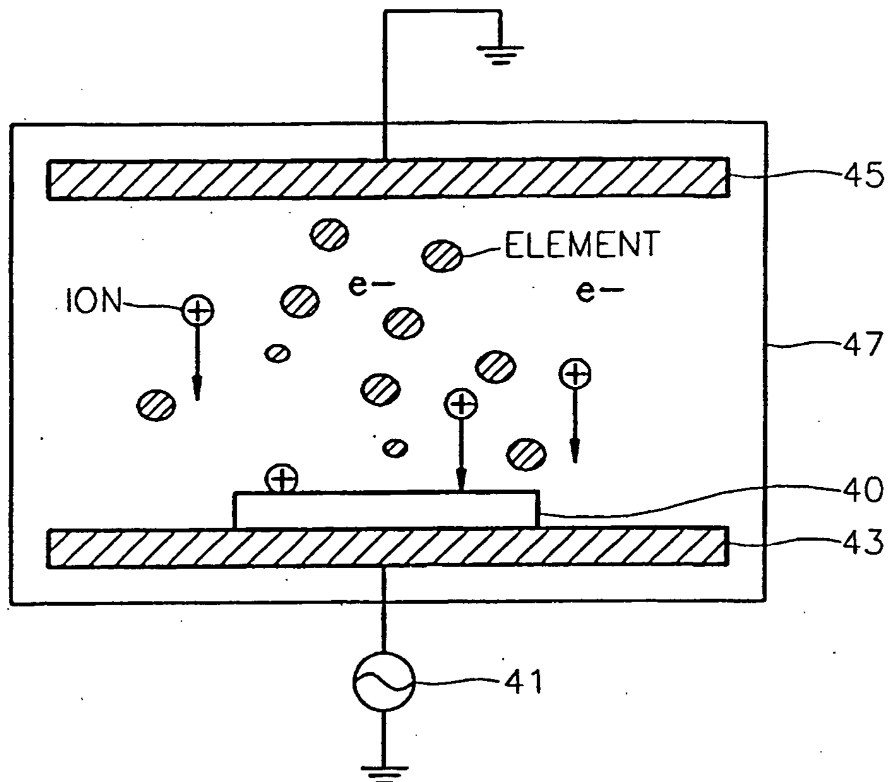


FIG. 2

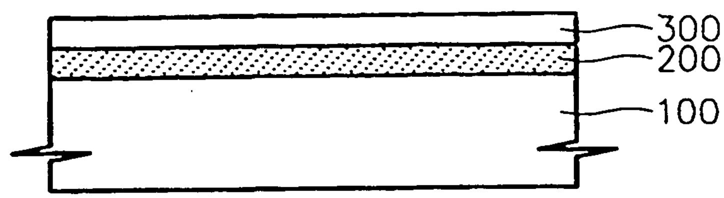


FIG. 3

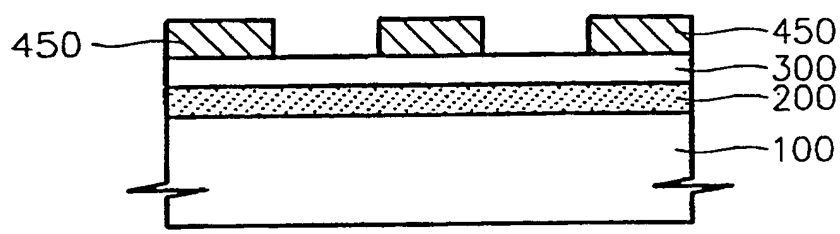


FIG. 4

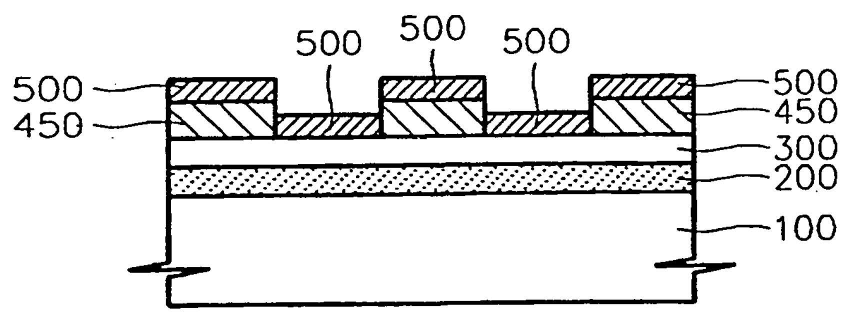


FIG. 5

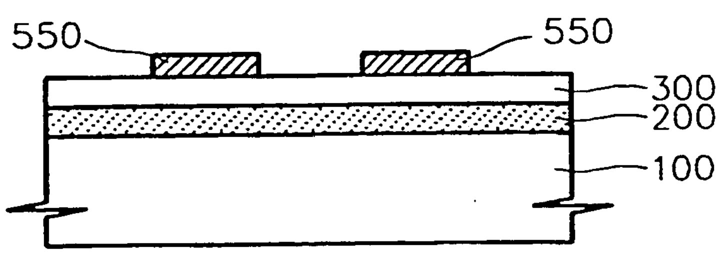


FIG. 6

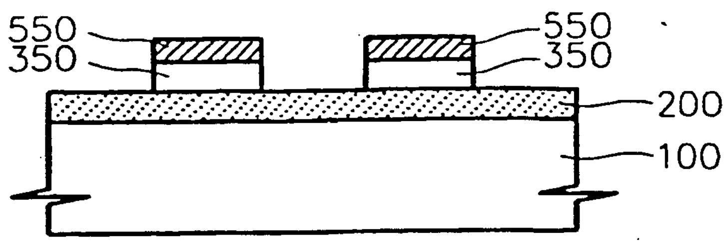


FIG. 7

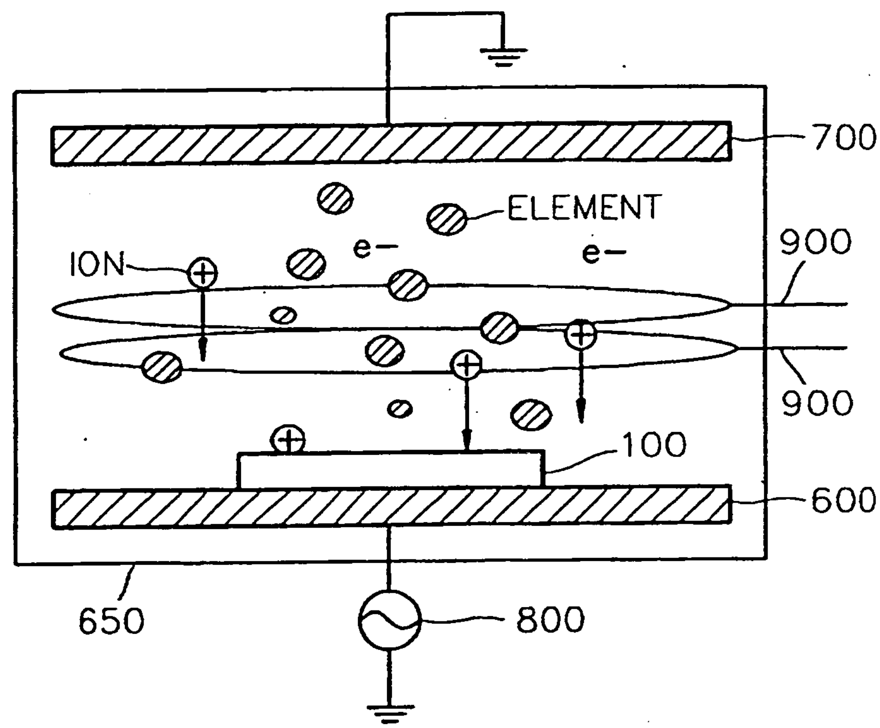


FIG. 8

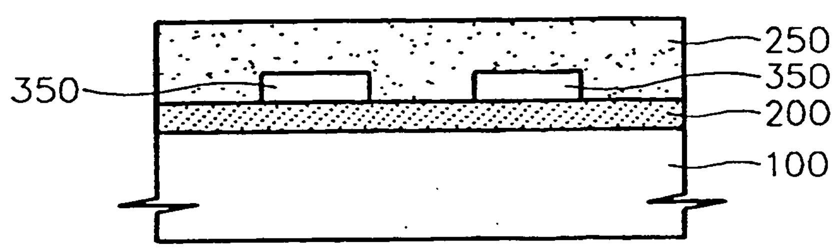


FIG. 9

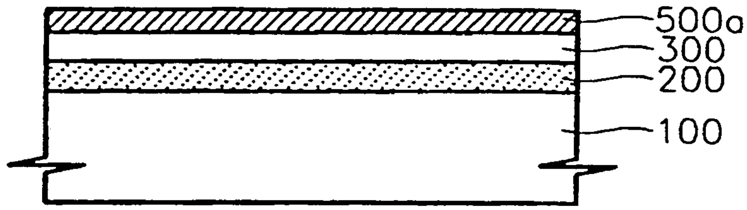


FIG. 10

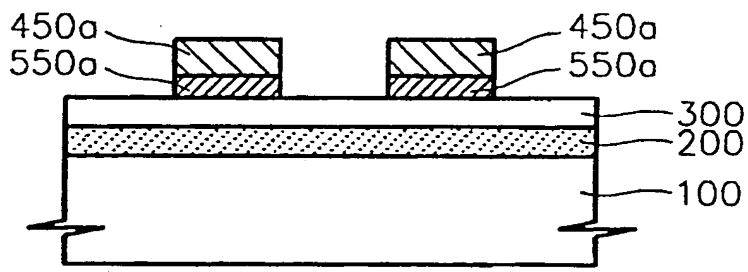
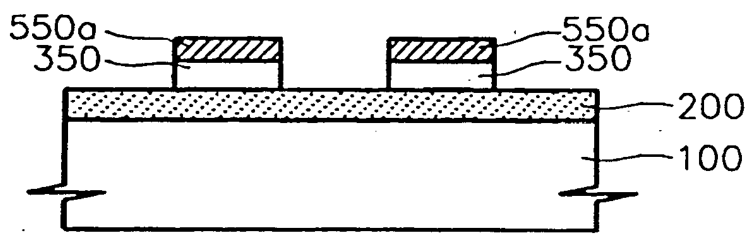


FIG. 11



METHOD OF MANUFACTURING OPTICAL WAVEGUIDE DEVICE USING INDUCTIVELY COUPLED PLASMA SYSTEM

The present invention relates to a method of manufacturing a device for optical communications, and more particularly, to a method of manufacturing an optical waveguide device.

An optical waveguide device is a basic optical transmission device for transmitting an optical signal, among several optical devices constituting a lightwave circuit.

The optical waveguide device includes lower and upper cladding layers formed on a substrate, and an optical waveguide for waveguiding light formed between the lower and upper cladding layers. The optical waveguide must be uniformly patterned to transmit light. To do this, a process for forming a core layer on the lower cladding layer and patterning the core layer is required.

The core layer is patterned by an etch process using a reactive ion etching (RIE) system as shown in FIG. 1.

To be more specific, a core layer and a mask pattern exposing a predetermined area of the core layer are sequentially formed on a substrate 40. The mask pattern is usually formed of photoresist. The resultant substrate 40 is loaded on a cathode electrode 43 of the RIE system as shown in FIG. 1. Radio frequency (RF) power generated by a RF power generator 41 is applied to the cathode electrode 43, and a direct current (DC) bias is applied to an upper electrode 45 spaced apart a predetermined distance and opposite to the cathode electrode 43. Simultaneously, a reactive gas is supplied into the RIE system to allow plasma to be generated from the reactive gas by the RF power applied to the cathode electrode 43. The thus-generated plasma reaches the substrate 40 and reacts with the core layer exposed by the mask pattern, thereby patterning the core layer. Then, the mask pattern, i.e., a remaining photoresist pattern, is removed.

In such an etching method using the RIE system, the etch speed is low. For example, when a silica layer is used as the core layer, the etch speed is very low, i.e., about 300Å/min to 500Å/min. Thus, in order to form an optical waveguide by etching a core layer having a thickness of about 8μm or more, etching for period of

about 3 to 5 hours is required. Therefore, the productivity of a process for manufacturing an optical waveguide device is degraded.

A method of increasing RF power can be used to increase the etch speed. In this method, the concentration of the generated plasma is increased by increasing the RF power, to thus increase the energy for etching. However, when increasing the RF power, another problem may occur in that the DC bias voltage applied to the upper electrode 45 increases to an abnormal level. Such an increase in DC bias may damage the optical waveguide or the lower cladding layer and substrate. This kind of damage lowers the characteristics of a lightwave circuit including an optical waveguide device.

Meanwhile, when the mask pattern is formed of photoresist, failure in photoresist pattern may be produced due to a restriction in the resolution depending on the thickness of the photoresist. This failure in photoresist pattern may generate defects in the profile or shape of the core layer pattern, i.e., optical waveguide. Thus, an optical transmission error may be generated.

To be more specific, the optical waveguide must generally be about 8μm high. Thus, the photoresist pattern thickness required for an etching process must be kept without being completely consumed until the core layer is completely etched out. An etch selection ratio of a material layer, i.e., a silica layer, used as the core layer to the photoresist pattern is about 1:1. Thus, a photoresist pattern having a thickness of about 10μm or more is required to etch the core layer having a thickness of around 8μm.

The restriction in the resolution is accompanied by exposure and development process for forming the photoresist pattern having the above-mentioned large thickness. Accordingly, photoresist pattern failures may be generated by the exposure or development inferiorities. Also, failure may be generated on the profile or shape of the core layer pattern, i.e., the optical waveguide obtained by the process for patterning the core layer using the failed photoresist pattern.

According to a first aspect of the invention there is provided a method as defined in Claim 1.

It is thus an advantage of the present invention to provide a method of manufacturing an optical waveguide, by which productivity is increased since a core

layer patterning process can be performed at high speeds.

In preferred embodiments of the method of manufacturing an optical waveguide, first, a lower cladding layer and a core layer are formed on a substrate. The core layer is a silica layer, an optical polymer layer, or a single crystal oxide layer.

A mask pattern exposing the core layer is formed on the core layer. The mask pattern is formed of a photoresist layer, an amorphous silicon layer, or a silicide layer. Alternatively, the mask pattern may be formed of a metal layer such as a chrome layer or a titanium layer. The metal layer is formed by sputtering or electron beam deposition.

The step of forming the mask pattern is performed as follows. A photoresist pattern exposing the core layer is formed on the core layer. The metal layer is formed on the resultant structure on which the photoresist pattern is formed. A metal mask pattern exposing the core layer is formed by removing the photoresist pattern while simultaneously removing a part of the metal layer formed on the photoresist pattern.

Alternatively, the step of forming the mask pattern may be formed as follows. The metal layer is formed on the core layer. A photoresist pattern exposing the metal layer is formed on the metal layer. A metal mask pattern exposing the core layer is formed by patterning the exposed metal layer using the photoresist pattern as a patterning mask. The step of patterning the exposed metal layer is performed using a dry or wet etching method.

The substrate having the mask pattern formed thereon is formed on a cathode electrode of an inductively coupled plasma system including the cathode electrode, an upper electrode opposing the cathode electrode at predetermined intervals, and an inductively coupled plasma coil interposed between the upper electrode and the cathode electrode.

A plasma from a reaction gas is generated by supplying the reaction gas to the inductively coupled plasma system and applying first and second RF power respectively to the cathode electrode and the inductively coupled plasma coil, to pattern the core layer exposed by the mask pattern, into an optical waveguide. The reaction gas includes a fluoride gas such as a carbon tetrafluoride gas or a sulfur hexafluoride gas. Then, an upper cladding layer covering the optical waveguide is

formed.

According to a second aspect of the invention there is provided a method as defined in Claim 12.

It is thus another advantage of the present invention to provide a method of manufacturing an optical waveguide, by which the profile, shape, or another aspect of an optical waveguide formed by achieving a thinner mask pattern can be improved by introducing a mask pattern having a high etch selectivity with respect to a core layer.

In preferred embodiments of a method of manufacturing an optical waveguide device, a lower cladding layer and a core layer are sequentially on a substrate. The core layer is a silica layer, an optical polymer layer, or a single crystal oxide layer.

A metal mask pattern exposing the core layer is formed on the core layer. The metal mask pattern is formed of a chrome layer or a titanium layer. The metal mask pattern is formed by sputtering or electron beam deposition.

The step of forming the metal mask pattern is performed as follows. A photoresist pattern exposing the core layer is formed on the core layer. The metal layer is formed on the resultant structure on which the photoresist pattern is formed. A metal mask pattern exposing the core layer is formed by removing the photoresist pattern while simultaneously removing a part of the metal layer formed on the photoresist pattern.

Alternatively, the step of forming the metal mask pattern may be performed as follows. The metal layer is formed on the core layer. A photoresist pattern exposing the metal layer is formed on the metal layer. A metal mask pattern exposing the core layer is formed by patterning the exposed metal layer using the photoresist pattern as a patterning mask. The step of patterning the exposed metal layer is performed using a dry or wet etching method.

The substrate having the metal mask pattern formed thereon is formed on a cathode electrode of an inductively coupled plasma system including the cathode electrode, an upper electrode opposing the cathode electrode at predetermined intervals, and an inductively coupled plasma coil interposed between the upper electrode and the cathode electrode.

A plasma from a reaction gas is generated by supplying the reaction gas to the inductively coupled plasma system and applying first and second RF power

respectively to the cathode electrode and the inductively coupled plasma coil, to pattern the core layer exposed by the mask pattern, into an optical waveguide. The reaction gas includes a fluoride gas such as a carbon tetrafluoride gas or a sulfur hexafluoride gas. Then, an upper cladding layer covering the optical waveguide is formed.

Further, advantageous, preferred features of the invention are defined in the dependent claims.

According to the present invention, productivity is increased since a core layer patterning process can be performed at high speeds. Also, a mask pattern having a high etch selectivity with respect to the core layer is employed, thus allowing improvement of the profile or shape of the optical waveguide formed by accomplishing a thinner mask pattern.

There now follows a description of preferred embodiments of the invention, by way of non-limiting example, with reference being made to the accompanying drawings in which:

FIG. 1 is a cross-section of a prior art reactive ion etching (RIE) system;

FIGS. 2 through 5 are cross-sectional views illustrating a method of preparing a mask pattern which is used in manufacturing an optical waveguide device according to a first embodiment of the present invention;

FIG. 6 is a cross-sectional view illustrating a step for manufacturing an optical waveguide using the mask pattern prepared according to the first embodiment of the present invention;

FIG. 7 is a cross-section of an inductively coupled plasma system which is used in manufacturing an optical waveguide;

FIG. 8 is a cross-sectional view illustrating a step of completing the optical waveguide device according to the first embodiment of the present invention; and

FIGS. 9 through 11 are cross-sectional views illustrating a method of manufacturing an optical waveguide device according to a second embodiment of the present invention.

The embodiments of the present invention can be modified into various other forms, and the scope of the present invention must not be interpreted as being restricted by the embodiments. The embodiments are provided to more completely explain the present invention to those skilled in the art. In the drawings, the shapes

or else of members are exaggerated or simplified for clarity. Like reference numerals in the drawings denote the same members.

FIGS. 2 through 5 are cross-sectional views illustrating a method of preparing a mask pattern which is used in manufacturing an optical waveguide device according to a first embodiment of the present invention.

FIG. 2 shows the step of forming a lower cladding layer 200 and a core layer 300 on a substrate 100.

To be more specific, the lower cladding layer 200 and the core layer 300 are sequentially formed on a flat substrate 100 made of silicon or glass. The core layer 300 is patterned later as an optical waveguide. Thus, the core layer 300 is formed of a material through which light can be guided or propagated. Also, the core layer 300 is formed of a material having a larger refractive index than the lower cladding layer 200.

For example, in the case of a silica optical waveguide, a silica layer containing oxidized silicon (SiO_2) as a main component is used as the core layer 300. Alternatively, the core layer 300 may be formed as an organic material layer such as a single crystal oxide layer or an optical polymer. The present embodiment takes as an example the case of using a silica layer as the core layer 300, but the present invention is not limited to the embodiment.

FIG. 3 shows the step of forming a photoresist pattern 450 on the core layer 300.

To be more specific, the photoresist pattern 450 exposing a predetermined area of the core layer 300 is formed on the core layer 300. Here, the photoresist pattern 450 covers a portion of the core layer 300 to be etched out later.

FIG. 4 shows the step of forming a metal layer 500 on the entire surface of the resultant structure on which the photoresist pattern 450 is formed.

The metal layer 500 is formed on the entire surface of the resultant structure on which the photoresist pattern 450 is formed. The metal layer 500 is formed of a metal having a large etch selectivity with respect to the core layer 300. That is, when the silica layer is used as the core layer 300, the metal layer 500 is formed of titanium (Ti) or chromium (Cr). Preferably, the metal layer 500 is formed of chromium (Cr).

The metal layer 500 is formed by a deposition method using a sputtering system or an electron beam deposition system.

FIG. 5 shows the step of forming a mask pattern 550.

The mask pattern 550 is formed by removing the photoresist pattern 450 and the metal layer 500 formed on the photoresist pattern 450 using a lift-off method. The lift-off method is performed using a chemical solvent. Here, the chemical solvent must be able to solve and remove the photoresist pattern 450 according to the quality of the material of the photoresist pattern 450. For example, acetone or the like is used as the chemical solvent. The chemical solvent solves and removes the photoresist pattern 450.

When the photoresist pattern 450 is solved, the metal layer 500 deposited on the photoresist pattern 450 is also removed. Thus, only the metal layer 500 deposited directly on the core layer 300 exposed by the photoresist pattern 450 remains, thereby forming the mask pattern 550.

As described above, the mask pattern 550 is formed of a material having a large etch selectivity with respect to the lower core layer 300. Accordingly, the mask pattern 550 can be formed more thinly than a mask pattern formed of photoresist. Thus, the metal mask pattern 550 can be accurately formed by the lift-off method.

The present embodiment describes the mask pattern 550 formed of the chrome layer as described above, but the material of the mask pattern 550 can vary according to the material of the core layer 300 to be patterned later. For example, the mask pattern 550 can use a metal layer such as titanium layer, a polymer layer such as a photoresist layer, an oxide layer such as an oxidized silicon layer, a dielectric layer such as amorphous silicon layer, or a silicide layer.

FIG. 6 is a cross-sectional view illustrating a step for forming an optical waveguide 350 by patterning the core layer 300. FIG. 7 is a cross-section of an inductively coupled plasma (ICP) system which is used in forming the optical waveguide 350.

The ICP system is comprised of a cathode electrode 600, an upper electrode 700 spaced apart a predetermined distance and opposite to the cathode electrode 600, and an ICP coil 900. A first RF power generated by a first RF power generator 800 is applied to the cathode electrode 600, and a DC bias is applied to the upper electrode 700. Also, a second RF power is applied to the ICP coil 900. The entire

configuration of the ICP system is similar to that of a conventional RIE system, except that the ICP coil 900 is introduced, and that the second RF power is applied to the ICP coil 900.

As described above, a substrate 100 on which the core layer 300 and the mask pattern 550 are formed is loaded on the cathode electrode 600 of the ICP system. A reactive gas is supplied into the ICP system via a gas supply line (not shown). A first RF power is applied to the cathode electrode 600, a second RF power is applied to the ICP coil, and a DC bias is applied to the upper electrode 700.

The elements of the reaction gas supplied into the ICP system are excited to a plasma phase by the first and second RF powers applied respectively to the cathode electrode 600 and the ICP coil 900. Here, the plasma is generated in various forms according to conditions such as the first RF power, the second RF power, a partial pressure in the ICP system, the type of reaction gas, the supply amount of the reaction gas, or the output of the ICP system.

The plasma contains elements of the reaction gas, ions excited from the reaction gas, a reactive radical, electrons, etc. Here, the excited ions are accelerated by the first RF power applied to the cathode electrode 600, and the accelerated ions collide with the substrate 100. This ion bombardment causes selective etching of the core layer 300 exposed by the mask pattern 550.

At this time, the movement of electrons (e^-) in the plasma is changed by the second RF power applied to the ICP coil 900. That is, the electrons in the plasma make a spiraling motion as well as a rectilinear motion. Accordingly, the electrons and the elements of the reaction gas, or the electrons and the ions in the plasma are more likely to collide with each other. Thus, the probability of generating plasma increases, to thus increase the concentration of plasma.

This increase in the concentration of plasma indicates an increase in the concentration of the ions in the plasma, radicals, or electrons. Such an increase in ions, etc. augments an ion bombardment effect, thus allowing faster etching of the core layer 300 exposed by the mask pattern 550.

In the present embodiment, a reaction gas including a fluoride gas is used as the reaction gas. For example, a carbon tetrafluoride gas (CF_4) which can generate carbon fluoride ion (CF_x^+) and fluorine radical, or a sulfur hexafluoride gas (SF_6)

which can generate fluorine ion and fluorine radical is supplied as the reaction gas.

This supplied fluoride gas is excited into a plasma phase by the first RF power applied to the cathode electrode 600 and the second RF power applied to the ICP coil 900. At this time, CF_x, CF_x^+, F_x, F^-, F and electron (e^-) exist within plasma which is generated when CF_4 is used as the reaction gas. Also, SF_x, SF_x^+, F_x, F^+, F and e^- exist within a plasma which is generated when SF_6 is used as the reaction gas.

Here, the F^+ or CF_x^+ is accelerated by the first RF power applied to the cathode electrode 600, and collides with the substrate 100. Accordingly, the core layer 300 is etched by the ion bombardment due to the F^+ or CF_x^+.

As described above, the concentration of ions which causes the ion bombardment due to the spiral motion of the e^- within the plasma by the second RF power applied to the ICP coil 900, such as F^+ or CF_x^+, is increased. Thus, the etch speed of the core layer 300 becomes higher.

In the present embodiment, an optical waveguide 350 having a thickness of about 8μm or more can be formed using concrete etch conditions which will be exemplified later. For example, about 10sccm (standard cubic centimeter per minute) to 50sccm of an SF_6 or CF_4 gas is supplied to an ICP system. Here, the air pressure in the ICP system is maintained at about 3 to 30mTorr. Also, about 10 to 400W of the first RF power is applied to the cathode electrode 600, and about 100 to 1500W of the second RF power is applied to the ICP coil 900.

Under the above-described etch conditions, the silica layer used as the core layer 300 can be etched at an etch speed of about 3000Å/min or higher. Here, when a chrome layer is used as the mask pattern 550, it can accomplish the etch selectivity with the core layer 300 (i.e., the chrome layer) of about 1:65. That is, when the chrome layer used as the mask pattern 550 is consumed by about 1Å, the silica layer used as the core layer 300 is etched by a thickness of about 65Å and removed.

Accordingly, the mask pattern 550, i.e., the chrome layer, can be introduced more thinly. A thinner lower photoresist layer for patterning the chrome layer using

the lift-off method can also be introduced, allowing accomplishment of a photoresist pattern in high-resolution. Thus, the profile or shape of the chrome layer pattern formed by the lift-off method, i.e., the mask pattern 550, is improved, so that a mask pattern 550 having a more accurate pattern is achieved.

An etch method performed under the etch condition of using the fluoride-family gas provides high anisotropic etching characteristics. Thus, the sidewalls of the optical waveguide 350 are sloped at almost right angles to the surface of the substrate 100. That is, the optical waveguide 350 having an excellent sidewall profile can be achieved, and more uniform sidewall characteristics can be obtained.

According to the first embodiment of the present invention, the optical waveguide 350 of 8μm or higher thickness having an excellent profile can be formed in a shorter time by the above-described effect.

FIG. 8 is a cross-sectional view illustrating a step of completing the optical waveguide device by forming an upper cladding layer 250 covering the optical waveguide 350.

After the mask pattern 550 remaining on the waveguide 350 is removed, the upper cladding layer 250 covering the waveguide 350 is formed. The upper cladding layer 250 is formed of a material having a lower refractive index than the material of the waveguide 350. Preferably, the upper cladding layer 250 is formed of the same material as that of the lower cladding layer 200.

FIGS. 9 through 11 are cross-sectional views illustrating a method of manufacturing an optical waveguide device according to a second embodiment of the present invention.

The same reference numerals in the second embodiment as those in the first embodiment denote the same members. In the first embodiment, the mask pattern 550 is formed by patterning the metal layer 500 using the lift-off method. However, in the second embodiment, a mask pattern 550a is formed by patterning a metal layer 500a using a selective etching process.

Referring to FIG. 9, the lower cladding layer 200 and the core layer 300 are sequentially formed on the substrate 100 as in the first embodiment. The metal layer 500a having a large etch selectivity with respect to the core layer 300 is formed on the core layer 300 according to the material of the core layer 300 to be etched. For example, the metal layer 500a is formed of Ti or Cr. The metal layer 500a is

formed by sputtering or electron beam deposition.

FIG. 10 is a cross-sectional view illustrating the step of forming the mask pattern 550a by patterning the metal layer 500a.

A photoresist pattern 450a exposing a part of the metal layer 500a is formed on the metal layer 500a. The exposed metal layer 500a is etched by using the photoresist pattern 450a as an etch mask, thereby forming the mask pattern 550a, i.e., a metal mask pattern, exposing a part of the core layer 300. A wet etching method or a dry etching method using a plasma can be used to etch the metal layer 500a.

The mask pattern 550a is formed of a metal having a large etch selectivity with respect to the lower core layer 300, so that it can be formed thinly. The photoresist pattern 450a for forming the mask pattern 550a can also be formed thinly, thus allowing formation of a photoresist pattern 450a in high-resolution. Therefore, the profile or shape of the mask pattern 550a is improved.

FIG. 11 is a cross-sectional view illustrating the step of forming an optical waveguide 350 by patterning the core layer 300.

The optical waveguide 350 is formed by etching a part of the exposed core layer 300 using an etching method using an ICP system. For example, the core layer 300 is selectively patterned by a reaction gas such as SF_6 or CF_4 gas. Thus, the effect as described in the first embodiment can be obtained. Then, the remaining etch mask 550a is removed, thus forming the upper cladding layer 250 as shown in FIG. 8.

As described above, the core layer can be patterned more quickly by using the reaction gas such as SF_6 or CF_4 and the ICP system which can generate fluorine ions or fluorocarbon ions. Therefore, productivity of manufacturing the optical waveguide device can be improved.

Also, a high etch selectivity with the core layer can be accomplished by introducing a metal mask pattern, etc., so that a thinner mask pattern can be introduced. Furthermore, high anisotropic etching characteristics can be achieved, allowing an excellent profile close to the perpendicularity of the optical waveguide to be formed.

The present invention was described in detail with reference to the above-

described embodiments, but the present invention is not limited to the embodiments. It is apparent that various modifications or improvements may be effected within the technical spirit of the present invention by those skilled in the art.

CLAIMS

1. A method of manufacturing an optical waveguide device, comprising the steps of:

sequentially forming a lower cladding layer and a core layer on a substrate;

forming a mask pattern exposing the core layer on the core layer;

loading the substrate on which the mask pattern is formed, on a cathode electrode of an inductively coupled plasma system including the cathode electrode, an upper electrode opposing the cathode electrode at predetermined intervals, and an inductively coupled plasma coil interposed between the upper electrode and the cathode electrode;

generating a plasma from a reaction gas by supplying the reaction gas to the inductively coupled plasma system and applying first and second RF power respectively to the cathode electrode and the inductively coupled plasma coil, to pattern the core layer exposed by the mask pattern, into an optical waveguide; and

forming an upper cladding layer covering the optical waveguide.

2. The method of manufacturing an optical waveguide device as claimed in claim 1, wherein the core layer is a layer selected from the group consisting of a silica layer, an optical polymer layer, and a single crystal oxide layer.

3. The method of manufacturing an optical waveguide device as claimed in claim 1 or claim 2, wherein the mask pattern is formed of a layer selected from the group consisting of a photoresist layer, an amorphous silicon layer, and a silicide layer.

4. The method of manufacturing an optical waveguide device as claimed in claim 1 or claim 2, wherein the mask pattern is formed of a metal layer.

5. The method of manufacturing an optical waveguide device as claimed in claim 4, wherein the metal layer is a layer selected from the group consisting of a chrome layer and a titanium layer.

6. The method of manufacturing an optical waveguide device as claimed in claim 4 or claim 5, wherein the metal layer is formed by sputtering or electron beam deposition.

7. The method of manufacturing an optical waveguide device as claimed in any of claims 4 to 6, wherein the step of forming the mask pattern comprises the substeps of:

forming a photoresist pattern exposing the core layer, on the core layer;

forming the metal layer on the resultant structure on which the photoresist pattern is formed; and

forming a metal mask pattern exposing the core layer by removing the photoresist pattern while simultaneously removing a part of the metal layer formed on the photoresist pattern.

8. The method of manufacturing an optical waveguide device as claimed in any of claims 4 to 6, wherein the step of forming the mask pattern comprises the substeps of:

forming the metal layer on the core layer;

forming a photoresist pattern exposing the metal layer, on the metal layer; and

forming a metal mask pattern exposing the core layer by patterning the exposed metal layer using the photoresist pattern as a patterning mask.

9. The method of manufacturing an optical waveguide device as claimed in claim 8, wherein the step of patterning the exposed metal layer is performed using a dry or wet etching method.

10. The method of manufacturing an optical waveguide device as claimed in any preceding claim, wherein the reaction gas includes a fluoride gas.

11. The method of manufacturing an optical waveguide device as claimed in claim 10, wherein the fluoride gas is one selected from the group consisting of a carbon tetrafluoride gas and a sulfur hexafluoride gas.

12. A method of manufacturing an optical waveguide device, comprising the steps of:

sequentially forming a lower cladding layer and a core layer on a substrate;

forming a metal mask pattern exposing the core layer on the core layer;

loading the substrate on which the metal mask pattern is formed, on a cathode electrode of an inductively coupled plasma system including the cathode electrode, an upper electrode opposing the cathode electrode at predetermined intervals, and an inductively coupled plasma coil interposed between the upper electrode and the cathode electrode;

generating a plasma from a reaction gas by supplying the reaction gas to the inductively coupled plasma system and applying first and second RF power respectively to the cathode electrode and the inductively coupled plasma coil, to pattern the core layer exposed by the mask pattern, into an optical waveguide; and

forming an upper cladding layer covering the optical waveguide.

13. The method of manufacturing an optical waveguide device as claimed in claim 12, wherein the core layer is a layer selected from the group consisting of a silica layer, an optical polymer layer, and a single crystal oxide layer.

14. The method of manufacturing an optical waveguide device as claimed in claim 12 or claim 13, wherein the metal mask pattern is formed of a layer selected from the group consisting of a chrome layer and a titanium layer.

15. The method of manufacturing an optical waveguide device as claimed in any of claims 12 to 14, wherein the metal mask pattern is formed by sputtering or electron beam deposition.

16. The method of manufacturing an optical waveguide device as claimed in any of claims 12 to 15, wherein the step of forming the metal mask pattern comprises the substeps of:

forming a photoresist pattern exposing the core layer, on the core layer;

forming the metal layer on the resultant structure on which the photoresist pattern is formed; and

forming a metal mask pattern exposing the core layer by removing the photoresist pattern while simultaneously removing a part of the metal layer formed on the photoresist pattern.

17. The method of manufacturing an optical waveguide device as claimed in claim 12 or any claim dependent therefrom, wherein the step of forming the metal mask pattern comprises the substeps of:

forming the metal layer on the core layer;

forming a photoresist pattern exposing the metal layer, on the metal layer; and

forming a metal mask pattern exposing the core layer by patterning the exposed metal layer using the photoresist pattern as a patterning mask.

18. The method of manufacturing an optical waveguide device as claimed in claim 17, wherein the step of patterning the exposed metal layer is performed using a dry or wet etching method.

19. The method of manufacturing an optical waveguide device as claimed in claim 12 or any claim dependent therefrom, wherein the reaction gas includes a fluoride gas.

20. The method of manufacturing an optical waveguide device as claimed in claim 19, wherein the fluoride gas is one selected from the group consisting of a carbon tetrafluoride gas and a sulfur hexafluoride gas.

21. Methods generally as herein described, with reference to or as illustrated in the accompanying drawings.

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Application No: GB 9821310.1
Claims searched: 1-21

Examiner: Graham Russell
Date of search: 23 December 1998

Patents Act 1977
Search Report under Section 17

Databases searched:

UK Patent Office collections, including GB, EP, WO & US patent specifications, in:

UK Cl (Ed.P):

Int Cl (Ed.6): G02B; H01J

Other: Online: EPODOC, WPI

Documents considered to be relevant:

Category	Identity of document and relevant passage		Relevant to claims
X	US 5658820	(SAMSUNG) see column 1 line 48-column 2 line 4	1-3
X	US 5607542	(APPLIED MATERIALS) see column 1 line 65-column 2 line 7	1-3
X	US 5534231	(MATTSON) see column 3 lines 46-53	1-3

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X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
		E	Patent document published on or after, but with priority date earlier than, the filing date of this application.
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